



Increasing Energy Ration of Bali Cattle to Improve Digestible Nutrient, Milk Yield and Milk Quality



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Abstract

To determine the effect of energy levels on digestible nutrient, milk production and milk quality of 7 months pregnant Bali cattle, was the purpose of this study. The study was conducted in Bali, Province of Indonesia on 12 pregnant breeding phase of pre-calving (2 months before the birth) with the parent body weight 329-340 kg/head. The treatment given is four types of Metabolizable Energy (ME) levels: 2000, 2100, 2200 and 2300/kg respectively as treatment A, B, C, and D. All ration contain 10% of crude protein. Variables measured: energy intake, digestible nutrient, milk yield, and milk quality. This research is a randomized block design. The results showed that increase energy ration until 2300 kcal ME/kg would significantly ($P<0.05$) increase energy intake and highest at cattle consumed ratio D is 22239.55 kcal/day. However, digestible nutrient was not affected. Milk production increased with increasing energy rations and highest ($P<0.05$) at cattle received treatment D is 2179.83 ml/day compared to treatment A 936.67 ml/day. Milk fat and milk lactose also highest ($P<0.05$) in treatment D are 8.56% and 4.76% respectively. Based on these results, it can be concluded that increase energy ration will increase energy intake, milk yield, and milk fat and milk lactose of Bali cattle.

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1. Introduction

Bali cattle are indigenous cattle with high fertility but produces low milk production. Bali cows are poor milk producer with almost invisible udder and lactation varying from 6 to 10 months, producing milk 0.9-2.8 kg/day (Sukarini, 2001). Nutrition of lactating cow affects the yield and proportion of milk components. Through the nutrient of the diet, the mammary gland is supplied with blood components to synthesize milk. Non-nutritional factors such as heredity, days in milk, parity, infections, and number of secretory cells, as well as temperature and humidity, often overshadow nutritional effects. The amount of milk produced by a cow is strongly influenced by the supply of nutrients into the udder gland secretory cells, so efforts to increase milk production can be done by increasing the entry of nutrients into cells.

Nutrient status of dam the last three months pregnancy considerable affect the calves cause of lower milk yield. According to Muktiyani *et al.*, (2005), cow's milk production is highly dependent on the amount of nutrient supply to the rudder gland secretory cells so that efforts to increase milk production can be done by increasing nutrient entry into cells. The primary nutrient limiting milk production is energy. After the high energy demands of the early lactation cow have been met the next limiting nutrient for increased milk production is Crude Protein (Kovler, 2003). During the period of gestation, there are some changes in physiological such as improvement of nutritional needs for the development of the fetus and rudder gland (Bell, 1995). Energy needs at the end of pregnancy increased rapidly because the uterus using nearly half of the available supply of glucose. Therefore, the energy needs of pregnant cow pre-calving phase 75% higher compared to cows that are not pregnant.

Edward LeViness (1993) states, pregnant cow age of 80-90 days before giving birth is a critical period because 1) must meet nutrient requirements for growth and also the development of the fetus where the weight gain reached triple, 2) maintain a strong body condition for birth which results in the healthy calf. Parent will give birth to weak calves too weak even, remain calf, 3) the parent produces milk with enough nutrients for the calf. In order for this requirement is reached, then Moran (2005) suggest, cows at 7 months gestation given increased energy ration of 10 ME (MJ/kg). On gestation 8 and a 9-month increase in energy demand reaching respectively 15 and 20 ME (MJ/kg).

Gong *et al.*, (2002) reported that sufficient dietary energy is an important factor in lactating animals which may prevent negative energy balance and other metabolic disorders. During, the lactation period, especially the dam needs an abundance of nutrient supply to meet the requirement of the high metabolic rate of the mammary gland for milk synthesis (Collier, 1985). Hoogendoorn and Grive (1969) reported that increased energy concentration in the ration gave a significant increase in milk production. Average daily milk production could be obtained by providing energy at about 100% (22.0 kg) rather than 90% (20.0 kg) of the National Research Council.

This study was therefore aimed to determine the effect of different energy levels in rations on digestible of dry matter, organic matter and nutrient, milk production and milk quality of 7 months pregnant Bali cattle.

2. Materials and Methods

Cattle

The study was conducted in Bali, Province of Indonesia on 12 pregnant breeding phase of pre-calving (2 months before the birth) with the parent body weight 329-340 kg/head. Each cow reared in individual cages. Given feed consists of forages and concentrates. Concentrate feed was given in the morning. While foraging given in the fresh state after a given feed concentrates. The composition of the ration is presented in Table 1 and the energy and protein content of the ration in Table 2.

Table 1
The composition of the ration treatment of pregnant Bali cattle

No	Ration Composition (%)	Treatments			
		A	B	C	D
1	Concentrate	35.000	37.000	40.000	43.000
2	King grass	64.255	61.020	56.660	51.125
3	Coconut oil	0.245	1.480	2.840	5.375
4	Vitamin/mineral	0.500	0.500	0.500	0.500

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Total	100.00	100.00	100.00	100.00
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Table 2
The nutrient content of the ration

No.	Nutrient of ration	Treatments			
		A	B	C	D
1	Crude Protein (%)	10.17	10.13	10.14	10.15
2	ME (kcal/kg)	2008.32	2100.00	2209.31	2300.00
3	Crude Fiber (%)	27.67	27.09	26.37	25.29
4	Calcium (%)	0.42	0.42	0.42	0.42
5	Phosphor (%)	0.27	0.27	0.27	0.26

Design of Experiments

Experiments using a randomized block design. The parent group treated with 4 different weight as replication. The treatment given is four types of metabolizable energy levels of ration: 2000, 2100, 2200 and 2300/kg respectively as treatment A, B, C, and D. All ration contain 10% of crude protein.

Variables Observed

Digestible Dry Matter, Organic Matter, Crude Protein and Crude Fiber

Digestible of Dry matter and nutrient measured by total collection period for 7 days. Observations over the total collection are done from 08:00 pm until 8:00 pm the next day. Ratio and the rest of the rations are taken each 200 g each day and at the end, the total collection was mixed and decomposed according to with their treatment. After that, taken each 200 g for analysis nutrient contain. The same was done to determine the content of nutrients in the feces. The digestible nutrient is calculated by the following formula:

Digestible Dry Matter (g/d) = Dry Matter Intake (g) – Dry Matter feces (g)

Digestible Organic Matter (g/d) = Organic Matter Intake (g) – Organic Matter feces (g)

Digestible Crude Protein (g/d) = Crude Protein Intake (g) – Crude Protein feces (g)

Digestible Crude Fiber (g/d) = Crude Fiber Intake (g) – Crude Fiber feces (g)

Milk Production

Milk production began to be measured one week after giving birth (Sukarini, 2000) to allow the calf to obtain colostrum from its mother. Milking is done twice, in the morning and afternoon. Milk production per day is the sum of the volume of milk milking morning and afternoon.

Milk Lactose

Milk lactose levels were analyzed using HPLC (High-Pressure Liquid Chromatography). Inserted into the test tube 1 ml of milk and 9 ml of distilled water. Once it's done 10 times dilution. A total of 1 ml of milk that has been diluted, added with 20 mL of precipitating protein, and then centrifuged. Which has been centrifuged supernatant for 7 minutes screened to then injected into the HPLC instrument?

$$\text{Milk Lactose} = \frac{\text{The area of the sample}}{\text{The area of standards}} \times 100\%$$

Milk Fat

Milk fat was measured using the method Babcock. 17.6 ml of milk + 17.6 concentrated sulfuric acid solution after cooled to a temperature of 15°C inserted into the Babcock bottles were centrifuged for 5 minutes. Then add hot water to a temperature of 90 ° C until the base of the neck bottles, centrifuge 2 minutes, the last added hot water to the bottle top scale, played again for 1 minute. On a scale marked on the neck of the bottle, can be read the percentage of milk fat samples.

Milk protein

Measurement of the protein content of milk is done with a macro-Kjeldahl through 3 phases: phase of destruction, distillation, and titration. Distillation resulting solution is then titrated with 0,1N HCl. If the color changes to pink, then that is the end point of the titration phase. Milk protein content is calculated by the following formula.

$$\text{Protein (\%)} = \frac{(a-b) \times 0.1 \times 14 \times 6.25}{\text{Sample Weight (mg)}} \times 100\%$$

Explanation:

- A = volume of HCl for titrate sample (ml)
- B = volume HCl for titrate blanko (ml)
- 0.1 = Normality of titrator (HCl)
- 14 = Equivalent Nitrogen (mg)
- 6.25 = Protein Factor

Blood Glucose

Blood samples were taken through the jugular vein after four hours of feeding. Blood glucose was measured using the glucose oxidase - phenol aminophenazone (GOD-PAP), with a spectrophotometer tool type 720. The principle of this method is glucose oxidase (GOD) will change the content of blood glucose into gluconate. Hydrogen peroxide (H₂O₂) formed in this reaction will be degraded by peroxidase (POD) and produce Phenol and 4-Aminoantipyrine compounds which can be measured through the Trinder indicator reaction at a wavelength of 505 nm. Increased absorbance correlates with blood glucose concentration.

Data Analysis

The data obtained in this study analyzed by analysis of variance. If the results are significantly different ($P < 0.05$) between treatments, the analysis followed by orthogonal contrast test at 5% level according to [Steel and Torrie \(1995\)](#).

3. Results and Discussions

3.1 Energy Intake and Digestible Nutrient

Increasing the energy content of the ration, will increase the digestible of dry matter and organic matter but statistically no significant different ($P > 0.05$). Energy intake of cows treated with treatment B, C and D respectively 2.09%; 5.36% and 7.94% higher than the treatment cows treated with treatment A, but statistically no significant different ($P > 0.05$). Increased energy ration will significantly improve its digestible energy. Digestible energy cows treated with ration B is 5, 39% higher compared to treatment A, but statistically not significantly different ($P > 0.05$).

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But the cows that received rations C and D, respectively 12.04% and 20.80% ($P < 0.05$) higher than treatment A. While the digestible of crude protein and crude fiber showed no significant differences ($P > 0.05$) among all treatments (Table 3).

Increased energy consumption is attributed to the increase in the digestibility of energy, also due to the energy content of the ration increased. Increased digestible Dry Matter, Organic Matter and intake of energy, causing the cattle got nutrient supply increases that are insufficient for the development of the udder so as to increase the milk production of 936.67 ml/d in ME ration of 2000 kcal/kg to 2179.83 ml/d in ME ration of 2300 kcal/kg. Energy consumption of Bali cattle are treated D is 22239.55 GE kcal/kg. This is equivalent to 74.37 MJ ME. In accordance with the recommendation [Moran \(2005\)](#), that the energy needs of a 7-month pregnant cow are 67 MJ ME/h.

Table 3
Energy intake and digestible nutrient of Bali cattle

Parameter	Treatment				SEM
	A	B	C	D	
Energy intake (GE kcal/d)	19526.32a	20301.13b	20943.85b	22239.55c	223.22
Digestible dry matter (g/d)	3012.33a	3075.23a	3173.68a	3251.48a	181.23
Digestible organic matter (g/d)	2647.10a	2689.75a	2768.57a	2832.89a	148.11
Energy fecal (kcal/d)	6843.12a	6934.14a	6733.78a	6918.85a	503.26
Digestible energy (kcal/d)	12683.20a	13366.99a	14210.07ab	15320.70b	474.43
Digestible crude protein (g/d)	422.11a	417.85a	405.13a	394.56a	12.89
Digestible crude fiber (g/d)	696.06a	714.13a	775.95a	823.98a	56.45

Explanations:

A= ration contain 10% Crude Protein and ME 2000 kcal /kg

B= ration contain 10% Crude Protein and ME 2100 kcal /kg

C= ration contain 10% Crude Protein and ME 2200 kcal /kg

D= ration contain 10% Cruse Protein and ME 2300 kcal /kg

Superscripts with different small letters in the same row indicate significant difference ($P < 0.05$) SEM = "Standard Error of the Treatment Means"

Digestible crude fiber, although statistically not significant but tends to increase with increasing energy rations and highest in rations contain ME 2300 kcal/kg. Unlike the case with digestible crude protein. Increasing energy ration, even more, decreased digestible crude protein. This is because ration A containing coconut oil is at least 0.245%. While treatment B, C, and D, the higher the coconut oil content is 1.480, 2.840, and 5.375%. Oil in the diet can inhibit the action of rumen microbes digest dietary protein.

3.2 Milk Yield and Milk Quality

Energy intake is positively related to the level of milk yield. The results showed increasing energy consumption, will produce a significant ($P < 0.05$) increase in milk yield. The provision of ME ration from 2000 kcal/kg to 2300 kcal/kg increase milk yield of 936.67 ml/day to 2179.83 ml/day (Table 4). [Brown et al., \(2005\)](#) reported that increase energy and protein intake will accelerate the growth of mammary parenchyma so could increase milk production. Because the number of mammary cells is a major factor limiting milk production. [Law et al., \(2011\)](#) reported that milk yield of a primiparous animal offered high energy and low energy diets were 29.7 and 24.8 kg/d respectively, and milk yield multiparous offered high and low energy diets were 33.5 and 28.2 kg/d respectively. Milk yield in this result no much different with the result of [Sukarini et al., \(2000\)](#), that the highest milk yield of the first lactation of Bali cows on grass-legume based diet was 2.08 kg/d. Otherwise, [Xue et al., \(2011\)](#) found that Holstein dairy cows gave 30% concentrate level produce milk 18.2 kg/d. The relationship between energy intake and milk yield in this result is equal to $Y = 0.36 X - 5840.5$. $R^2 = 0.69$, where Y = milk yield and X = energy intake (Figure 1).

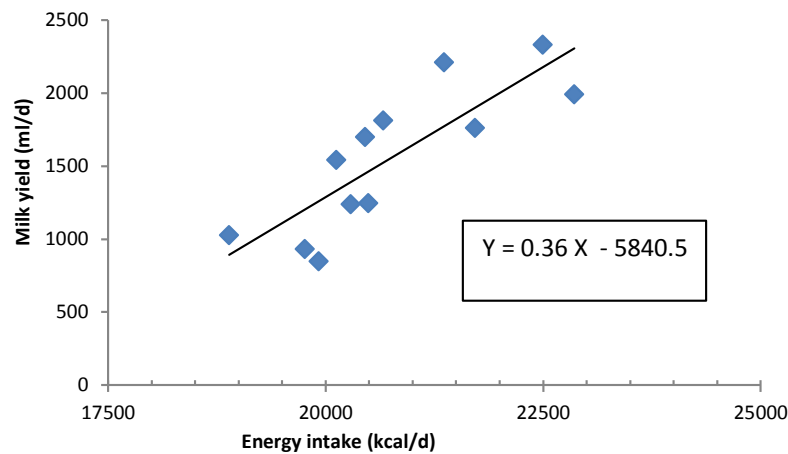


Figure 1. The relationship of energy intake with a milk yield of Bali cattle

There is no significant effect of increased energy ration on milk protein concentration ($P > 0.05$), but a trend towards increased levels of milk protein to energy ration increased from 3.99% to 4.18%. Increased energy ration a significant effect ($P < 0.05$) the concentration of milk fat and milk lactose. Provision Bali cattle with a ration containing ME 2300 kcal/kg increase milk fat 7.81% and increased milk lactose 22.05% than cow's received rations containing ME 2000 kcal/kg.

Level energy ration significantly affects the concentration of milk lactose. Milk lactose of this result range from 3.90 – 4.76%. This is equivalent to results by [Xue et al., \(2011\)](#) were Holstein dairy cows gave 30% concentrate produce milk lactose is about 4.52% and Holstein dairy cows gave 70% concentrate produce milk fat is about 3.85%. Holstein-Friesian cows in 300 days lactating produce milk lactose 4.96 – 5.02% ([Grainger et al., 2009](#)). The relationship between energy intake with milk lactose in this research follows the formula: $Y = 5,75 \ln X - 52,79$. $R^2 = 0,56$. X = energy intake, Y = milk lactose and presented in Figure 2.

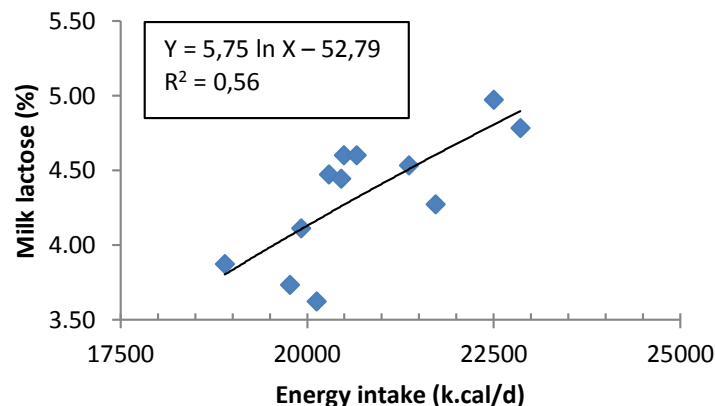


Figure 2. The relation of energy intake with milk lactose

Milk fat content of Bali cattle is quite high when compared to other cows. Milk fat content of Bali cattle results of the study ranged from 7.94 - 8.96% (Table 4). The higher the energy content of the ration, the milk fat concentration also increased. [Sukarini \(2001\)](#), which examines the mammary performance on the first lactation of Bali cattle also get milk fat concentration of 7.79% - 8.18%. Between and within breeds, fat varies the most and lactose the least ([Woodford et al., 1986](#)). On the contrary, [Suherman \(2005\)](#) who studied the ratio of native grass to concentrate (70: 30) to the quality of milk production of Holstein cow, found that milk fat content is 4.81%. [Gurmessa and Melaku](#)

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(2012) also reported that milk fat of bred cross Holstein Friesian cows in early and late lactation was $4.46\% \pm 1.44$. According to Woodford *et al.*, (1986), between and within breeds, fat varies the most and lactose the least. Milk fat originates from 4 major pathways and one of them is directly from the diet (Stoop *et al.*, 2009). The relationship between energy intake and milk fat of this research follows the formula: $Y = 3,53 \ln X - 26,91$. $R^2 = 0,43$. X = energy intake, Y = milk fat.

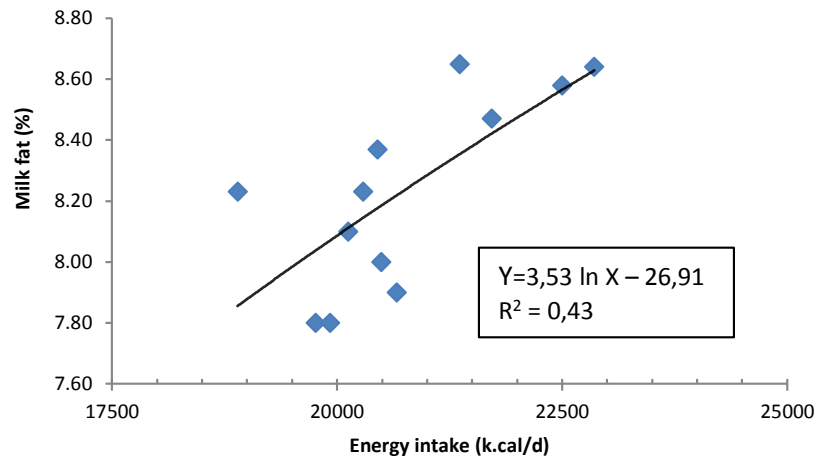


Figure 3. The relation of energy intake with milk fat

Blood glucose in this research gave a slightly high value after *partum* than before, but statistically no significant effect. The lower blood glucose levels prior to parturition due to uptake by cells for prepare mammary glands for producing milk and for growing fetus. Glucose is a major component of cow's milk so that is a critical nutrient of cows in the postpartum stage (Lucy *et al.*, 2014). According to the research conducted by Sukarini *et al.* (2001), the glucose plasma concentration of Bali cattle fed grass-legume based diet at peak lactation was 86.0 mg/dl, higher than the result of this study. Glucose kinetic of Bali cattle either at peak lactation or during dry condition was not affected by ration quality.

Table 4
Effect of level energy ration on milk yield and milk quality of Bali cattle

Parameter	Treatment				SEM
	A	B	C	D	
Milk yield ml/d	936.67a	1344.33b	1757.90c	2179.83d	75.675
Milk Quality					
Milk Dry Matter (%)	18.62a	19.09a	19.46a	18.85a	0.217
Milk protein (%)	3.99a	3.84a	4.03a	4.18a	0.098
Milk fat (%)	7.94a	8.11a	8.25ab	8.56b	0.108
Milk lactose (%)	3.90a	4.23ab	4.44bc	4.76c	0.144
Blood glucose					
Before partum (mg/dl)	59.00a	56.00a	58.00a	58.00a	3.184
After partum (mg/dl)	63.67a	63.00a	64.67a	62.67a	1.980

Explanations:

- A= ration contain 10% Crude Protein and 2000 kcal ME/kg
- B= ration contain 10% Crude Protein and 2100 kcal ME/kg
- C= ration contain 10% Crude Protein and 2200 kcal ME/kg
- D= ration contain 10% Cruse Protein and 2300 kcal ME/kg

Superscripts with different small letters in the same row indicate significant difference ($P < 0.05$) SEM =

4. Conclusion

There is no significant effect on digestible nutrient with improving metabolizable energy level from 2000 kcal/kg until 2300 kcal/kg on Bali cattle ration. But, milk yield and milk quality increase significantly.

Conflict of interest statement and funding sources

The author(s) declared that (s)he/they have no competing interest. The study was financed by the authors.

Statement of authorship

The author(s) have a responsibility for the conception and design of the study. The author(s) have approved the final article.

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